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Yoshinobu Aoyagi

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EXAMINER

SONG, MATTHEW J

ART UNIT

PAPER NUMBER

1765

DATE MAILED: 06/15/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/941,612

Applicant(s)

AOYAGI ET AL.

Examiner

Matthew J Song

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 02 April 2004.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 4-36 is/are pending in the application.  
4a) Of the above claim(s) 22-25 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 4-21 and 26-36 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

## Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date 6/5/2003.

- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 4-21, 26-28 and 33-36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nishizawa et al (US 5,693,139) in view of Edmond et al (US 5,739,554).

Nishizawa et al discloses a method of growing doped semiconductor monolayers, note entire reference, comprising raw material gases of Gallium (Ga) and Arsenic (As), where Ga is supplied for 0.5 to 10 seconds, the chamber is evacuated, this reads on applicant's purged for a predetermined time, and As is supplied for 2 to 200 seconds and

the cycle is repeated (col 7, ln 1-67; col 8, ln 1-30 and Fig 7B and Fig 11). Nishizawa et al also discloses a p-type layer is formed by introducing an impurity gases and Ga simultaneously but alternately with an As source, where the impurity gas is an Mg, Zn or Cd containing gas or Silane. Nishizawa et al also discloses a n-type layer doped with Se or S and the impurity gas is introduced cyclically with the Ga gas and As gas or the impurity gas and Ga gas are introduced simultaneously but alternately with the As gas (col 8, ln 31-60). Nishizawa et al also discloses forming pnp bipolar transistors (col 8, ln 61-67). Nishizawa et al also discloses nozzles 44, 45 and 46 for introducing gaseous compounds used for impurity doping for introducing group II, IV and VI gases (col 10, ln 50-67). Nishizawa et al also discloses different modes of doping, where the dopant is added at the exhaustion of an As gas, the introduction of a Ga gas, the exhaustion of a Ga gas or at the introduction of As gas (col 11-13 and Fig 11). Nishizawa et al also discloses other III-V semiconductors are applicable to the invention (col 14, ln 5-55). Nishizawa et al also discloses introduction of a Ga source gas and a group II dopant simultaneously to form a p-type layer (col 8, ln 30-45) and the introduction of a group IV dopant after the introduction of a Ga source gas (col 15, ln 5-50). Nishizawa et al also discloses selection of the timing of doping with respect of the source gas introduction is based on the desired dopant type for the monolayer being grown (col 15, ln 45-55).

Nishizawa et al does not disclose the given time for supplying each of the impurity raw materials are close to each other.

Edmond et al teaches a gallium nitride (GaN) layer co-doped with both a Group II acceptor and Group IV donor (col 4, ln 50-67), where the group II acceptors include Zn or Mg and the Group IV donors include Si or Ge (col 6, ln 20-50), this reads on

applicant's the time for supplying each of the impurity raw materials are close to each other. Edmond et al also discloses the GaN layer is formed by CVD, where Trimethylgallium (TMG), ammonia, silane and biscyclopentadienyl magnesium,  $(\text{Cp})_2\text{Mg}$  are used as reactant gases (col 7, ln 45-67 and col 8, ln 1-50). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Nishizawa et al with Edmond et al to form a co-doped GaN layer useful as an active layer (Abstract).

The combination of Nishizawa et al and Edmond et al is silent to forming impurity pairs within at least one of the crystal raw materials. The combination of Nishizawa et al and Edmond et al teach supplying similar raw materials and impurities, as applicant. Also, the combination of Nishizawa et al and Edmond et al teach a similar method of supplying raw materials, purging and supplying impurities, as applicant. Therefore, the plural types of impurity raw forming impurity pairs within at least one of the crystal raw materials is inherent to the invention taught by the combination of Nishizawa et al and Edmond et al. The inherent forming of impurity pairs using co-deposition is evidenced by Pankove (US 4,028,720) and Anayama et al (US 5,799,027), below.

The combination of Nishizawa et al and Edmond et al is silent to causing a decrease in activation energy and an increase in carrier concentration. The combination of Nishizawa et al and Edmond et al inherently teach forming impurity pairs of similar raw materials and impurities, as applicant, therefore a decrease in activation energy and an increase in a carrier concentration is inherent because impurity pairs are formed. The formation of similar impurity pairs will be expected to have the same results of

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decreasing the activation energy and increasing carrier concentration. Furthermore, Applicant has admitted that the activation energy is decreased and the carrier concentration is increased as a result of forming impurities pair, note page 19, lines 11-17 of the reply filed on 8/25/2003, which provides evidence of the decrease in activation energy and increase in carrier concentration is inherent when impurity pairs are formed.

Referring to claim 4, the combination of Nishizawa et al and Edmond et al teaches forming a co-doped GaN layer using Mg and Si dopant, where the compound semiconductor layer is grown in monolayer by alternate introduction of source gases and the chamber being evacuated continuously throughout the whole method ('139 col 3, ln 35-45) and the Si is introduced after the Ga source gas to act as a donor and a Ga source and a Mg dopant are introduced simultaneously but alternately with a As source.

Referring to claim 5, the combination of Nishizawa et al and Edmond et al teaches the introduction of a group IV dopant after the introduction of Ga and prior to the introduction of As and the introduction of group II dopant after the introduction of Ga and prior to the introduction of As (col 13, ln 10-35 and Fig 11).

Referring to claim 6-10, the combination of Nishizawa et al and Edmond et al teaches Ga as a first raw material gas and As or N as a second raw material gas.

Referring to claim 11-20, the combination of Nishizawa et al and Edmond et al teaches a co-doped layer with p-type and n-type impurities.

Referring to claim 21, the combination of Nishizawa et al and Edmond et al teaches using a silane dopant gas. The combination of Nishizawa et al and Edmond et al does not teach using a TESI dopant gas. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of

Nishizawa et al and Edmond et al by substituting TESi gas for silane because TESi is an equivalent Si source for doping and substituting equivalents for the same purpose is obvious (MPEP 2144.06).

Referring to claim 33-36, the combination of Nishizawa et al and Edmond et al teaches supplying reactants for a short period of time ('139 col 11, ln 50-60), this reads on applicants pulsed manner.

3. Claim 21 and 33-36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nishizawa et al (US 5,693,139) in view of Edmond et al (US 5,739,554) as applied to claims 4-21 and 26-28 above, and further in view of Manabe et al (US 6,472,690).

The combination of Nishizawa et al and Edmond et al teaches all of the limitations of claim 21, as discussed previously, including using silane as a Si dopant. The combination of Nishizawa et al and Edmond et al does not teach supplying TESi

In a method of forming a gallium nitride compound semiconductor, note entire reference, Manabe et al teaches forming an  $n^+$  type Gallium nitride layer, using silane or tetraethylsilane (TESi) (Example 4). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nishizawa et al and Edmond et al with Manabe et al because substituting known equivalents for the same purpose is obvious (MPEP 2144.06).

Referring to claim 33-36, the combination of Nishizawa et al, Edmond et al and Manabe et al teaches supplying reactants for a short period of time ('139 col 11, ln 50-60), this reads on applicants pulsed manner.

4. Claims 29-32 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nishizawa et al (US 5,693,139) in view of Edmond et al (US 5,739,554) as applied to claims 4-21 and 26-28 above, and further in view of Daly (US 5,231,298).

The combination of Nishizawa et al and Edmond et al teaches all of the limitations of claim 29, as discussed previously, except the impurity raw materials are placed at a close relationship with each other at a predetermined ratio without incorporating disorder into the crystal layer.

In a method of making a strain-free GaAs device, note entire reference, Daly teaches the epitaxial deposition of a strain-free, carbon doped p-type layer in a GaAs device to from the base layer thereof in a manner that includes the balancing of the strain of the crystal lattice structure caused by the carbon doping by co-doping the base layer with an isovalent and isoelectronic dopant, which also inhibits defect formation (Abstract), this reads on applicants without incorporating disorder into the crystal layer because strain from the impurity is balanced. Daly also teaches the amount of co-dopant required to counteract the carbon induced strain in the GaAs layer is proportional to the amount of carbon employed for p-doping (col 2, ln 50 to col 3, ln 20), this reads on applicants predetermined ratio. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nishizawa et al and Edmond et al by controlling the co-dopant to prevent strain as taught by Daly to form a strain free layer.



5. Claims 32 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nishizawa et al (US 5,693,139) in view of Edmond et al (US 5,739,554) and Manabe et al (US 6,472,690), as applied to claim 21 above, and further in view of Daly (US 5,231,298).

The combination of Nishizawa et al, Edmond et al and Daly teaches all of the limitations of claim 32, as discussed previously, except the Mg and Si are placed at a close relationship with each other at a predetermined ratio without incorporating disorder in a layer of Ga.

In a method of making a strain-free GaAs device, note entire reference, Daly teaches the epitaxial deposition of a strain-free, carbon doped p-type layer in a GaAs device to from the base layer thereof in a manner that includes the balancing of the strain of the crystal lattice structure caused by the carbon doping by co-doping the base layer with an isovalent and isoelectronic dopant, which also inhibits defect formation (Abstract), this reads on applicants without incorporating disorder into the crystal layer because strain from the impurity is balanced. Daly also teaches the amount of co-dopant required to counteract the carbon induced strain in the GaAs layer is proportional to the amount of carbon employed for p-doping (col 2, ln 50 to col 3, ln 20), this reads on applicants predetermined ratio. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nishizawa et al and Edmond et al by controlling the co-dopant to prevent strain as taught by Daly to form a strain free layer.

### ***Response to Arguments***

6. Applicant's arguments with respect to claims 29-36 have been considered but are moot in view of the new ground(s) of rejection.

7. Applicant's arguments filed 4/2/2004 have been fully considered but they are not persuasive.

Applicants' argument that Pankove (US 4,028,720) and Anayama et al (US 5,799,027) cannot aid the rejection of record is noted but is not found persuasive. Applicants' allege that Pankove and Anayama et al are not included in the rejection, therefore cannot aid the rejection. The basis of the rejection is over the combined teachings of Nishizawa et al and Edmond et al. The combination of Nishizawa et al and Edmond et al does not teach certain claimed features, which the Examiner has address by stating the features are inherent to the combination of Nishizawa et al and Edmond et al. Pankove and Anayama et al are merely provided as support for the Examiner's position of inherency and are not relied upon for the basis of the rejection. However, the teachings are still relevant to the rejection of record.

In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., impurity pairs form a donor-acceptor complex without a net conductivity (pg16)) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993).

Applicants' argument that Edmond et al merely teaches the prior art co-doping and does not teach the concept of co-doping is noted but is not found persuasive.

Applicants' allege that Edmond et al teaches a "net conductivity", therefore does not teach the concept of impurity pairs. The Examiner admitted in the rejection that Edmond et al does not teach forming impurity pairs. The Examiner maintains that impurity pairs are inherently formed. Applicants argue that the formation of impurity pairs is only accomplished by carefully controlling the timing, note page 17 of the Reply filed 4/2/2004. Applicants also teach supplying p-type and n-type impurity raw material synchronously with the raw material A, note page 12 of the specification. The combination of Nishizawa et al and Edmond et al teaches supplying the p-type and n-type dopants synchronously, as applicants; therefore the carefully control is taught by the combination of Nishizawa et al and Edmond et al. Because the combination of Nishizawa et al and Edmond et al teaches a similar method of supplying dopants, as applicants, the effect of forming impurity pairs is inherent to the combination of Nishizawa et al and Edmond et al. Furthermore, the references, which applicants have improperly chosen not to consider, Pankove (US 4,028,720) and Anayama et al (US 5,799,027) below also provide evidence that impurity pairs are formed when reactants are co-doped.

Applicants' argument that Edmond et al does not show the control and timing of the raw materials is noted but is not found persuasive. Applicants teach supplying p-type and n-type impurity raw material synchronously with the raw material A, note page 12 of the specification. The combination of Nishizawa et al and Edmond et al teaches co-doping, which is a method of supplying the p-type and n-type dopants synchronously, as applicants; therefore the carefully control is taught by the combination of Nishizawa et al and Edmond et al.

*Conclusion*

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Pankove (US 4,028,720) teaches gallium and arsenic, as impurities are co-deposited together with silicon on a wafer to form molecular impurity pairs (col 3, ln 30-45 and col 4, ln 1-5).

Anayama et al (US 5,799,027) teaches pairing probabilities of p and n type impurities can be lowered with the crystal plane used when impurities are doped at the same time (col 18, ln 55-67).

Goetz et al (US 6,441,393) teaches a nitride layer is co-doped using co-dopants of Si/Ge, Si/Sn an Ge/Sn to stabilize the structural integrity of the a III-V nitride on a lattice mismatched substrate (col 5, ln 45-65).

Merriam-Webster teaches a pulse is a dose of a substance esp. when applied over a short period of time (pg 946).

Nishizawa et al (EP 0439064) teaches supplying reactant gases at different times in relation to compound gases (pg 7).

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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Matthew J Song  
Examiner  
Art Unit 1765

MJS

NADINE C. NORTON  
SUPERVISOR EXAMINER

A handwritten signature in black ink, appearing to read "Nadine", written over the printed name and title.